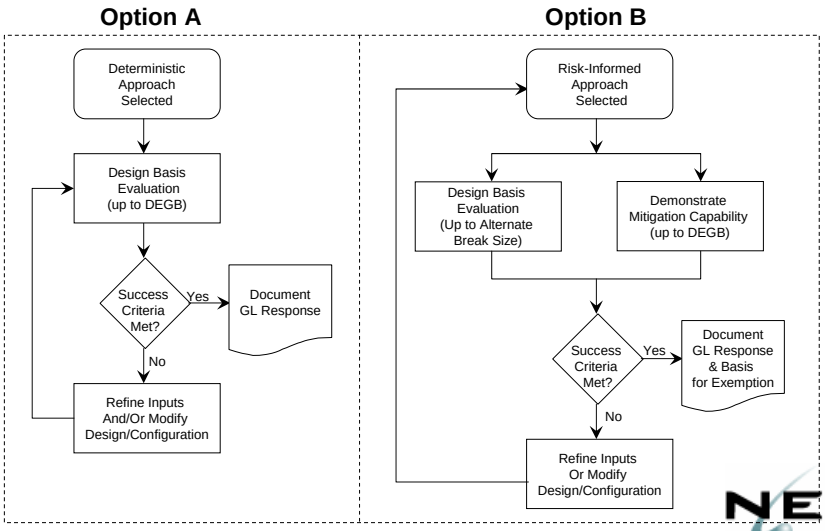
Risk-Informed GSI-191 Resolution

May 25, 2004

Philosophy of Risk-informed GSI-191 Approach

- Provide Option for Risk-informed Compliance That:
  - Defines New Design Basis "Alternate Break Size" Based on Risk-informed Principles
  - Retains Requirement to Demonstrate Mitigation Capability Using Realistic Methods and Inputs
  - Assures Incremental Risk is acceptably small

PWR Containment Recirculation Sump Performance Evaluation Process Overview



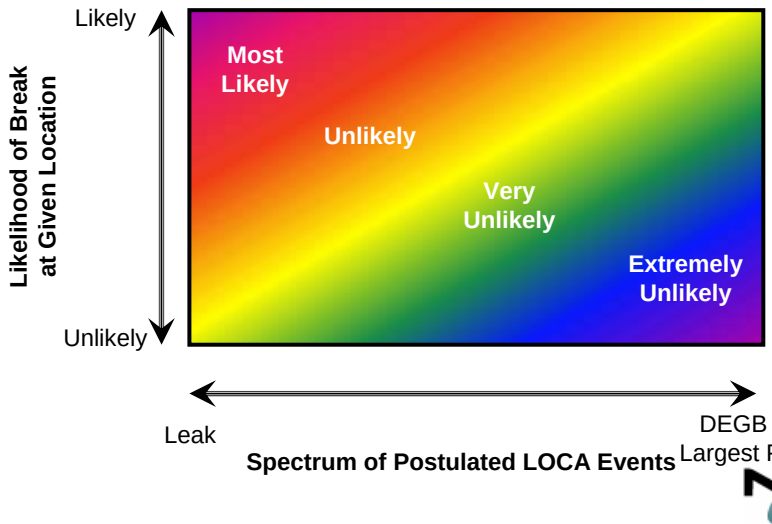
Alternate Break Size

- Various Alternate Break Size (ABS) proposals are being considered, including
  - Area equivalent to a DEGB of the largest attached piping to RCS main loop piping, and
  - Area established using 1E-6 frequency at 95% confidence level of SECY 04-0060
- For purposes of process illustration, the first sub-bullet proposal has been used throughout this presentation
- Using this ABS, the Design Basis Analyses would include all auxiliary lines and all break locations in main loop piping for sizes up to ABS

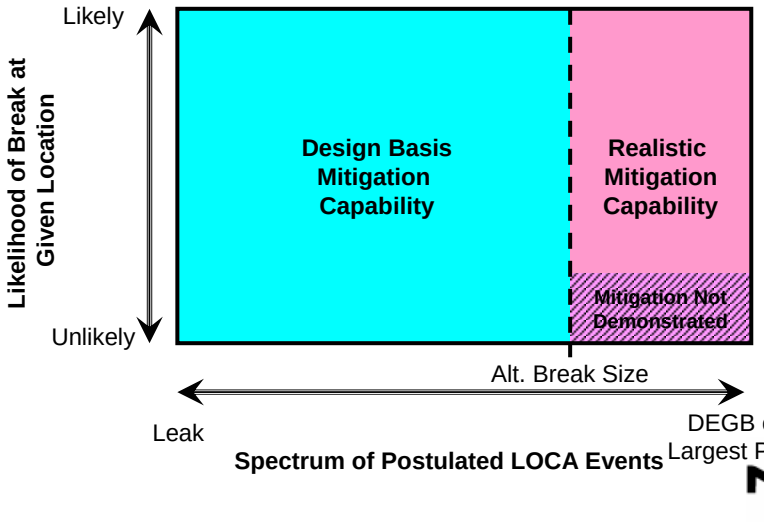
Break Spectrum Coverage

- The spectrum of possible primary side breaks can be examined as a function of location and effective break size
- This acknowledges that the frequency of a given break size is typically dominated by a few break locations

Likelihood of Postulated LOCAs

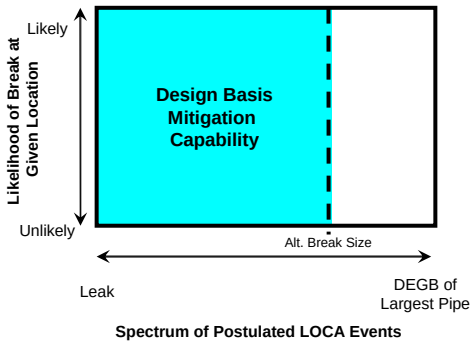


Risk-informed Approach to Spectrum of Postulated LOCAs



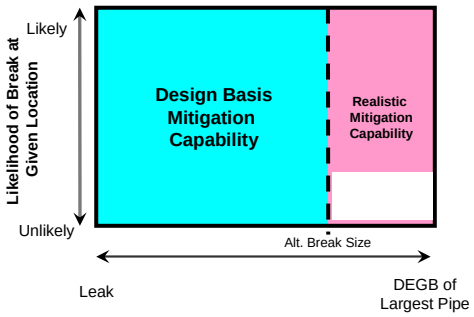
Spectrum addressed by RI Design Basis Analysis

- Spectrum of break sizes up to Alternate Break Size
- Full spectrum of locations addressed
- Includes all breaks in Categories 3 & 4 of Elicitation Effort
- Includes major contributors to Categories 5 & 6 of Elicitation Effort
  - Surge line
  - RHR line
  - Hot leg breaks (up to alternate break size)



Spectrum addressed by Mitigation Capability Analysis

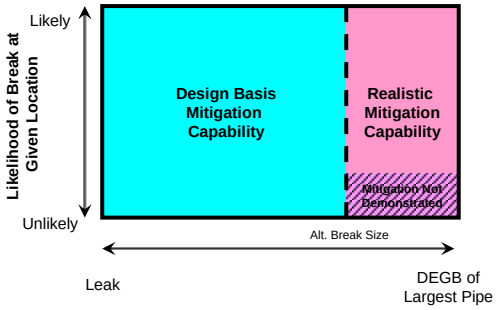
- Spectrum not addressed by Design Basis analysis is Main Loop piping with effective break area greater than Alternate Break Size
- Mitigation Capability Analysis addresses expected break locations for this remaining spectrum of breaks
  - High stress and fatigue locations (nozzles, weld attachments) per MEB 3.1



Spectrum of Postulated LOCA Events

Combination of Design Basis Analysis and Mitigation Capability Analysis

- The combination of Design Basis and Mitigation Capability analyses addresses a broad spectrum of LOCA events
- Remaining spectrum limited to unlikely break sizes occurring at unlikely locations



Spectrum of Postulated LOCA Events

Risk-Informed GSI-191 Resolution (Option B)

- Two separate sets of technical analyses to be performed
  - Design Basis Analyses
  - Demonstration of Mitigation Capability
- Incorporation of analyses into licensing basis also requires
  - Exemption Request
  - Regulatory Basis for Exemption Request

Design Basis Analyses

- Design Basis Analyses performed in same manner as Deterministic Analysis (Option A) except that maximum break size set by "Alternate Break Size"
- Sump performance analyses performed in conservative manner consistent with deterministic design basis analyses

Demonstration of Mitigation Capability

- Performed to demonstrate that mitigation capability is retained for break sizes between ABS and DEGB of largest pipe in RCS at expected break locations
- Analysis can be performed using modification of conservative DBA methods, assumptions and success criteria
  - Use of realistic vs. conservative inputs
  - Eliminate non-mechanistic assumptions
  - Nominal vs. Bounding
  - Credit for non-safety equipment and operator actions
- Consistent with analysis methods used to support Plant-specific PRAs

Demonstration of Mitigation Capability

- Guidance will direct the use of DBA methodology with identified set of modifications
- Necessary to simplify the review, acceptance and performance of DMC analysis

DMC – Modifications of DBA Analysis

- **Break Sizes**
  - Range of break sizes from ABS to full DEGB of largest attached piping
- **Break Locations**
  - Main Loop Piping locations identified using SRP 3.6.2* and MEB 3.1**
  - Addresses locations susceptible to high stress and fatigue

* SRP 3.6.2, *Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping*

** Branch Technical Position MEB 3.1, *Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment*

DMC – Modifications of DBA Analysis

- **Break Configuration**
  - Circumferential breaks assumed to result in pipe severance and separation amounting to at least one-diameter lateral displacement unless physically limited by piping restraints, structural members, or piping stiffness as may be demonstrated by analysis
  - Limited pipe displacements at the break location, line restrictions, flow limiters may be taken into account, as applicable

DMC – Modifications of DBA Analysis

- **Analysis Assumptions**
  - No coincident loss of offsite power or assumed single failure
  - Nominal Thermal/Hydraulic Conditions
  - Debris Source Term
    - Developing recommendations for "nominal" latent debris source term and relaxation of treatment of unqualified coatings
  - Credit for Non-safety equipment and operator actions

DMC – Modifications of DBA Analysis

- **Success Criteria**
  - Conservative application of NPSH criterion utilizing more realistic calculation assumptions
  - Demonstrate NPSH margin for minimum number of ECCS injection pumps
  - Demonstrate long-term containment cooling capability
  - Time-variable nature of required and available NPSH can be considered
  - Limited operation in cavitation (negative NPSH margin) can be considered, where justified
  - Nominal parameters used in NPSH calculation
    - Containment sump temperatures and levels
    - Containment backpressure
    - ECCS flow

Exemption Request

- Plant-specific exemption request via 10 CFR 50.12
- Exemption to 10 CFR 50.46 definition of LOCA for application to 10 CFR 50.46 (b)(5), *Long-term cooling* requirements
- License change request will also address application of analysis to regulatory requirements for CSS recirculation

Regulatory Basis for Exemption Request

RG 1.174 Risk-Informed Principle	GSI-191 Option B Approach
1. The proposed change meets the current regulations unless it is explicitly related to a requested exemption or rule change	• A specific exemption to 50.46(c)(1) for application to 50.46(b)(5) will be requested under 10 CFR 50.12.
2. The proposed change is consistent with the defense-in-depth philosophy	• Design basis mitigation capability demonstrated for breaks up to ABS • Demonstration of realistic mitigation capability for >ABS
3. The proposed change maintains sufficient safety margins	• Safety margins maintained for spectrum of credible breaks
4. When proposed changes result in an increase in core damage frequency or risk, the increases should be small and consistent with the intent of the Commission's Safety Goal Policy Statement	• Risk neutral or risk benefit expected • Residual risk for larger LOCAs in unlikely locations is negligible • Evidence indicates that the total frequency of DEGB breaks is $<10^{-7}$/yr
5. The impact of the proposed change should be monitored using performance measurement strategies	• In Service Inspection of RCS Piping will identify degradations • Containment Housekeeping/FME programs

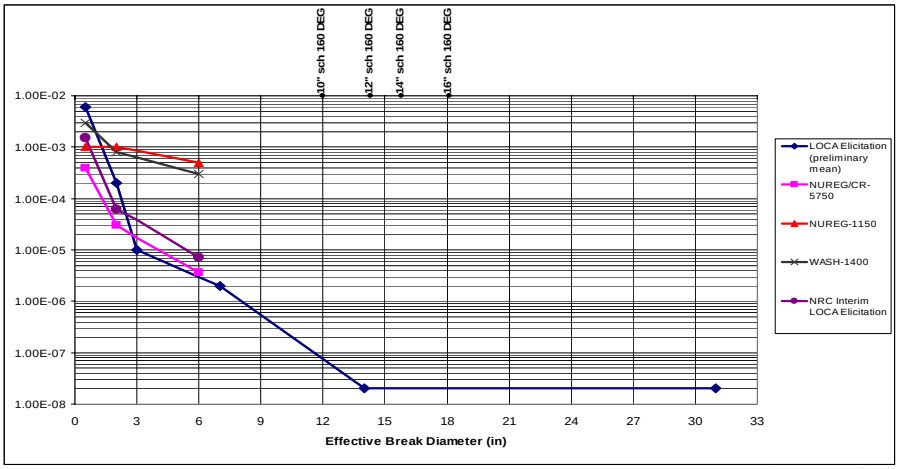
Insights from LOCA Frequency Estimations

- Downward trend of break frequency with increasing break size seen in all frequency estimation efforts
- Break frequency at larger sizes is dominated by locations with know stressors and precursor events (e.g., high stress, fatigue, PWSCC, thermal stratification)
- From SECY 04-0060:
  - *For the category 3 and 4 LOCAs, the safety injection and CVCS lines are the most consistently identified contributors. The concern with these lines is thermal fatigue.*
  - *For the very large category 5 and 6 LOCAs, the important systems are the hot leg, surge line, and RHR lines. PWSCC is the primary concern in the hot leg and surge line… There is an additional concern with thermal fatigue in the surge line due to thermal stratification. The concern with the RHR lines is potential environmental attack and the large number of precursor events reported for these lines.*

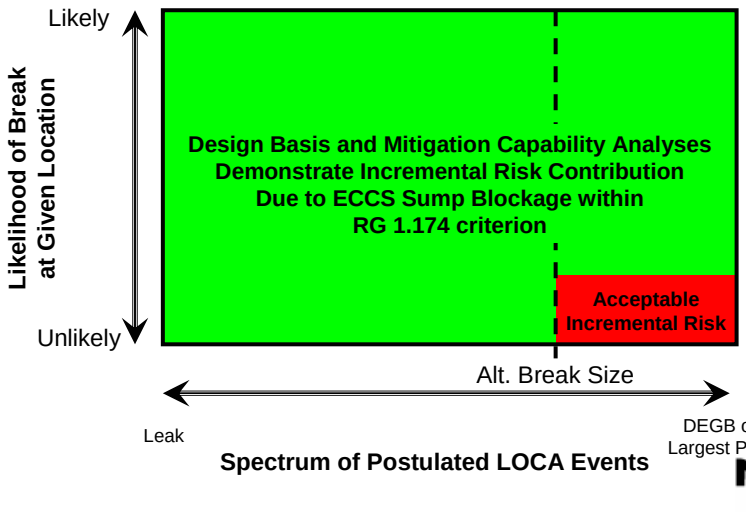
Application of LOCA Frequency Estimation Insights

- Design Basis Analysis covers:
  - Safety Injection and CVCS lines identified as major contributor to Categories 3 and 4
  - Surge line and RHR line breaks identified as major contributors to Categories 5 and 6
  - Hot leg breaks up to a size equivalent to break in largest attached piping
- Mitigation Capability Analysis covers:
  - Remaining susceptible locations and break sizes up to full DEGB

LOCA Frequency Estimations



Residual Risk From Proposed Approach



Incremental Residual Risk From Option B Approach

- Incremental Risk Over Complete Design Basis Analysis Limited By Demonstration of Realistic Mitigation Capability up to DEGB of Largest Pipe for susceptible locations
- Some Residual Incremental Risk Could Exist For Very Large Breaks In Unlikely Break Locations
- However, Frequency of Such LOCAs $<<10^{-6}$/yr
- Plant-specific Risk Analysis Not Required
  - Avoids complications in development of PRA models simulating debris generation, debris transport and headloss

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